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ABSTRACT

The purpose of this study was mainly to: (1) assess the competencies of pre-service biology teachers in identifying and correcting student misconceptions about photosynthesis; (2) search for relationships which might exist between each competency and a set of four independent variables, namely, background knowledge about photosynthesis, field-independent/field-dependent cognitive style, previous teaching practice of photosynthesis, and previous experience of scoring students' written assignments or tests; and (3) select the best predictors of each competency from this set of independent variables. The subjects selected for the study consisted of 200 prospective teachers enrolled in two colleges of education in Egypt. An instrument was developed by the investigator to measure the competencies of identifying and correcting misconceptions about photosynthesis. In general, the findings of this study imply that teacher training institutions should develop training programs that increase pre-service teachers' competencies in diagnosing and correcting students' misconceptions. (Author/TW)

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ABSTRACT

The Competencies of Pre-Service Egyptian Biology Teachers In Identifying and Correcting Misconceptions about Photosynthesis in A Written Answer : An Evaluative and Correlational Study

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The purpose of this study was mainly to : (1) assess the competencies of pre-service biology teachers in identifying and correcting student misconceptions about Photosynthesis; (2) search for relationships which might exist between each competency and a set of the following four independent variables : (a) background knowledge about photosynthesis; (b) field-independent/field-dependent cognitive style; (c) previous teaching practice of photosynthesis and (d) previous experience of scoring students' written assignments or tests; and (3) select the best predictors of each competency from this set of independent variables.

The subjects selected for the study consisted of 200 prospective teachers enrolled at the Biology Section in two colleges of Education, Egypt. An instrument was developed by the investigator to measure the competencies of identifying and correcting misconceptions about photosyrthesis. This instrument mainly included an essay answer. Ten common misconceptions about photosynthesis were embedded in this answer. The respondents to the instrument were informed to identify and then to correct in writing any misconception encountred in that answer. The study's findings demonstrated that : (1) few misconceptions were identified and corrected by fifty percent or more of the subjects, (2) among the four independent variables, only the background knowledge about photosynthesis was correlated significantly ($P < 0.0001$) high with the competencies of identifying and correcting misconceptions (3) the four independent variables were relatively succeeded, in predicting both competencies (4) only the background knowledge about Photosynthesis was selected by the stepwise procedure as the best predictor of the competency of identfying misconceptions; and (5) a subset of variables including the background knowledge about photosynthesis, previous teaching practice of photosynthesis; and previous experience of scoring students' written assignments or tests was selected by the stepwise method as the best predictors of the competency of correcting misconceptions. In general, the findings of this study imply that teacher training institutions should develop training programs that increase pre-service teachers' competencies in diagnosing and correcting, students' misconceptions.

Introduction

In recent years, students' misconceptions in science subject areas have become of considerable interest to science education researchers all over the world (see, e.g., Helm & Novak, 1983; Pfundt & Duit, 1985; Treagust, 1985). Now, it is well established that students bring with them to science classes certain misconceptions that are highly stable in their cognitive structures. It is likely that these misconceptions hinder students' concepual change as a major task of science instruction (Strike & Posner, 1982).

Since students' misconceptions are so critical in their learning science, science educators have begun to view successful science instruction as a process of changing students' misconceptions to more scientific conceptions (e.g., Roth, Smith & Anderson, 1983; Fisher & Lipson, 1986). Apparently, diagnosing and correcting these misconceptions are the two major instructional processes needed for bringing about this change. In this concern, Strike and Posner (1982) state:

> Accomodation [changing misconceptions] is Likely to occur if instruction can be organized so that teachers can spend a substantial protion of their time in diagnosing and correcting errors in student thinking. (P. 239)

Because of the importance of the two processes in changing students' misconceptions, some science educators see that our problem with students' misconceptions will persist unless our teachers are capable of diagnosing and

correcting them (see, e.g., Griffiths & Grant, 1985; Doran; 1972; Nussbuam, 1979).

Accordingly, two questions are raised here. First, are our teachers competent in doing the processes of identifying and correcting students' misconceptions' ? Secondly, do we have any empirical data related to the evaluation of these two processes on the part of science teachers?

Review of literature, unexpectedly, reveals that only one study (Nussbaum, 1979), to be discussed next, was addressed partially to assessing student-teachers' competency in diagnosing some science misconceptions. However, no attempt was made in Nussbaum's study to assess the competency of these teachers in correcting misconceptions. In addition, Nussbaum's study did not deal with any other teachers' variables related to the competencies of identifying and correcting misconceptions. Hence, additional studies on the area of teachers' competenies in identifying and correcting misconceptions are warranted. The first priority in these studies might be given to the assessement of both competencies in science topics where students show numerous misconceptions. Among these topics are photosynthesis (Treagust & Haslam, 1986), heat (Erickson, 1980), chemical equilibrum (Wheeler & Kass, 1978), and many others (see Helm & Novak, 1983).

These additional studies might also be addressed to search for relationships that might exist between each competency and some other teachers variables. Among these variables are : teachers background knowledge in science, cognitive styles, teaching experience and others. Studying these relationships might be of practical significance for developing both competencies among science teachers. Moreover, studying these relationships might be taken one step further. That is to predict each competency from other teachers' variables.

In short, the field of teachers' competencies in identifying and correctiong students' misconceptions is in need of further investigations. Priority in this field might be given to studies that evaluate both competencies among science teachers and that which correlate and predict each competency from some other teachers' variables.

The Purpose

The purpose of this study was mainly to : (1) assess the competencies of pre-service biology teachers in identifying and correcting students' misconceptions about photosyntnesis;(2) search for relationships which might exist between each competency and a set of the following four

variables; (a) background knowledge about photosynthesis; (b) field-independent/field-dependent cognitive style; (c) previous teaching practice of photosynthesis, and (d) previous experience of scoring students' assignments or tests; and (3) select the best predictors of each competency from this set of independent variables.

Definition of Terms

The followings are definitions for the key terms in this study:

Misconception about Photosynthesis -- The term "misconception" is particularly problematic (Fisher & Lipson, 1986). Many different definitions have been given to this term in literature. Among these definitions are : (1) paradigm-specific, limited or in appropriate propositional hierachies (Novak, 1983); (2) "unaccepted (though not necessarily 'incorrect') interpretation of a concept by the learner" (Wandersee, 1986, P. 581); (3) "an evaluative term that refers to an improper or incorrect conceptual framework. It indicates a mismatch between framework held by a person (or group of persons) and the correct one". (Hoz, 1983, P. 154); (4) "obvious connotation of a wrong idea" (Driver & Easley, 1978, P. 62); and (5)"students' conceptions which are different from those generally accepted by the scientific community". (Treagust, 1986, P. 1). Moreover, the term

'misconception' is somewhat used alternatively with other terms such as :"conceptual mistake"(Nussbaum, 1979),"alternative framework"(Driver, 1981),"Preconception"(Novak, 1977), "Concept misunderstanding" (Marek, 1986),"error"(Fisher & Lipson, 1986),"erroneous idea or alternative conception" (Fisher, 1985) and"naive conception"(Bishop, Roth & Andersen, 1986). In this study,the term "misconconceptions about photosynthesis", refers to a student's written conceptions about the photosynthesis's process that are judged by this investigator with the help of college botanists and experienced biology teachers as worng, incorrect, or erroneous conceptions.

Competency of Identifying Misconceptions -- the teachers' skill of specifying in writing the misconceptions embedded in a student's answer about photosynthesis. This competency is measured by"The Identifying & Correcting Misconceptions Scale"(ICMS) developed by this investigator.

Competency of Correcting Misconceptions -- the teachers' capability to write the correction for the misconceptions included in a written answer about photosynthesis.

This competency was measured by"The Identifying & Correcting Misconception Scale"(ICMS) developed by the investiagator.

Background Knowledge about Photosynthesis -- the fundamental propositions about photosynthesis that are constructed previously on the teacher cognitive structure as a result of reception or discovering learning experiences. This background knowledge was measured by "The Photosynthesis Achievement Test" (PAT) developed by the investigator.

Field-Independent/Field-Dependent Cognitive Style -- A measure of psychological perception of a field. The person with a more field-independent way of perceiving tends to experience his surroundings analytically--with objects experienced as discrete from their backgrounds. The person with a more field-dependent way of perceiving tends to experience his surroundings in a relatively global fashion, passively conforming to the influence of prevailing field or context (Witkin, Dyk., Fatheron & Karp, 1962, P. 35). In this study, this cognitive style was measured by The Group Embedded Figures Test (Witkin, Oltman, Raskin & Karp, 1971).

Previous teaching Practice of Photosynthesis -- the teacher previous field experience of delivering lessons in the topic of photosynthesis during student teaching training.

This pratice is determined by The Field Experience Data from (FEDF) developed by the investigator.

Previous Experinence of Scoring Students' Assignments or Tests -- the teachers' previous training on correcting students' homework or essay type tests. This experience was determined by The Field Experience Data Form (FEDF) developed by the investigator.

Prediction -- The process of determining the numerical value of a criterion variable on the basis of known value of two or more predictor variables (Good, 1973, P. 433).

Prediction Efficiency -- the percentage of the variability in each of the competencies of identifying and correcting misconceptions explained by the independent variables. Operationally, this efficiency is determined by the squared multiple correlation coefficient (R-square, R^2).

Prediction Equation -- A linear equation for predicting a criterion variable from two or more predictor variables, the coefficients of the predictor variables being so chosen as to make the sum of the squares of the differences between the actual and the predicted values of the criterion variable

a minimum (Good, 1973, P. 486). The raw score (nonstandardized) formula of the prediction equation is :

$$y = a + b_1x_1 + b_2x_2 \ \ldots \ b_nx_n$$

where :

y is the predicted criterion score;

a is a constant (intercept);

x's are the independent variables (predictors); and

b's are the partial regression coefficients.

Review of Related Literature

In this concern two groups of previous studies are reviewed. The first of these studies are that evaluate the teachers' competency in identifying students' misconceptions in science related areas. The second, are the investigations that reported results related to students' misconceptions about photosynthesis.

It is indicated earlier in this paper, that the number of researches that belong to the first group of studies is perhaps very limited. Only the study of Nussbaum (1977) was addressed partially to assessing the competency of ninety-four Israli student-teachers in diagnosing misconceptions. The assessment was carried out by giving these teachers an answer sheet that includes a student's conceptions about

the nature of matter. Three misconceptions were embedded in this answer. Those student-teachers were asked to identify in writing any misconception in the answer. Meanwhile, they were informed to propose the possible reasons for those misconceptions. Here are some findings of Nussbaum's study: (1)A very small number of subjects, 7 out of 94 (7%) identified all three misconceptions; 2) two misconceptions were identified by 24 (26%) and one misconception was identified by 42 student teachers (45%); and 3) the majority of the subjects (86 out of 94) made some general remarks about the reasons of the misconceptions. Nussbaum viewed these remarks as having no interpretative quality or any diagnostic value.

As for the second group of studies, review of literature revealed that students' understanding of the process of photosynthesis has been investigated by a number of researchers including Wandersee (1983, 1986); Simpson and Arnold, (1982); Roth, Smith and Anderson (1983); Anderson, Shelden, and DuBay (1986); and Treagust & Haslam (1986). On the whole, these studies have investigated the conceptions of photosynthesis in a variety of different populations ranging from fifth grade to college. The findings of these studies tend to be quite censistent with each other showing that the majority of students at all levels hold numerous misconceptions about

Photosynthesis. These misconceptions are reported in detail elsewhere (Anderson et al., 1986; Treagust & Haslam, 1986).

Theoretical Framework

It is assumed in this study that whenever a teacher examines students' conception, he tends to compare it with a model answer constructed previously in his congnitive structure , or background knowledge. If this conception is partially or totally invariance with this model answer, the teacher would designate it as a misconception. Then, he may use this model answer to correct this misconception to his students. Presumably, if the used model answer is scientifically correct, the teacher may be judged as competent in identfying and correcting that misconception.

Furthermore, it is assumed that the teacher's model answers developed for a school topic are derived from his general background knowledge about this topic. Consequently it is expected that this background knowledge is perhaps correlated positively with the teachers' competencies in identifying and correcting students' misconceptions.

However, someone might argue that a teacher could designate students' notion as a misconception even when his model answer about this notion is scientifically incorrect.

For example, a teacher might judge the following notion as misconception : plants do not respire. His judgement is right, but it may depend on a faulty model answer. That is, the plants respire only at night. Apparently, this teacher model answer is not scientifically correct because plants respire during the day or night.

The above example may also explain the case in which we find some teachers are able to identify a misconception but can not provide an accepted scientific correction for it.

It is also hypothesized here that a teacher's competency in identifying misconceptions embedded in an essay answer could be related to his capability of perceptual disembeding. This capability deals with breaking up an organized field in order to seperate out a part of it. That capability is one of congnitive styles called:Field-independent/field-dependent cognitive style (Witkin et al., 1962). The person who performs in relatively field-independent fashion tends to percieve a perceptual field analytically whereas the relatively field-depenent person percieve the field globally and cannot overcome its embededness. Assuming that the essay answer is a perceptual field including articulated notions, it is expected that the field-independant teacher will be able to

seperate out more notions than the field-dependent one. Seperating out these notions is perhaps the first step towards teacher's evaluation of the correctedness of students' notions. Accordingly, it is expected that the field-dependent teacher might identify more misconceptions in an essay answer than the field-dependent one. Perhaps this expectation is only effective if both teachers are equivalent in other variables related to misconception's identification.

Moreover, it is expected that Teachers' competencies in identifying and correcting student's misconceptions about a scientific topic (e.g., photosynthesis) could be related to their previous teaching pratice of that topic. This expectation is based on an assumption that is teaching a specific topic would provide a teacher with operative opportunity to encounter students' misconceptions about this topic during classroom discussions. Once these opportunities are repeated, the teachers might become more acquainted with these misconceptions as well as their corrections. Furthmore it is hypothesized in this study that teachers' competencies in identifying and correcting misconceptions in written answers, might be correlated positively with their previous experience of scoring students' written assignments or tests. It is supposed that this experience might make the teacher more

conversant with the process of judging students' notions and specifying some of them as missonceptions. This experience might also provide teachers with some general discernments about the kinds of students' misconceptions and how to correct them.

In short, it is expected that the competencies of identifying and correcting misconceptions are correlated positively with the following set of teachers' variables : (1) background knowledge about photosynthesis; (2) Field-independent/field-dependent cognitive style; (3) previous teaching practice of photosynthesis, and (4) previous experience of scoring students' assigniments or tests. Accordingly, it is hypothesized that this set of variables could predict these two competencies.

Method

Subjects

The subjects who participated in this study consisted of 200 prospective science teachers (175 females and 25 males). These subjects are randomly selected from a total population of 380 seniors. They are enrolled at The Biology Section in two Egyptian Colleges of Education, The College of Education, Alexandria University and The College of Education, Tanta University, during the school year 1986/1987. All subjects

were expected to work as science teachers starting with the school year 1987-1988. The age of subjects ranged from 21.2 to 25.4 years with an average of 21.8 years. (SD = 1.3).

Instrumentations

Four papers and pencil instruments were used for data collection, (1) The Field Experience Data Form (FEDF), (2) The Photosynthesis Achievement Test (PAT), (3) The Identifying & Correcting Misconceptions Scale (ICMS); and (4) The Group Embedded Figures Test (GEFT). The first three instruments were constructed by this investigator[1]. A Destription of the above instruments follows :

1) The Feild Experience Date Form (FEDF).

This self report one page form was constructed according to the guidelines of the questionnaire design provided by Matthews (1979). This form is intended to collect data about subjects' field experience in teaching lessons on photosynthesis and in scoring assignments or tests. It also collects data about subjects' previous college study for the topic of "diagnosing learning errors". The respondents to this form are asked to answer three items by circling"yes"or"no"replies. These items are : (1) have you ever taught the topic of

(1) Copies of the instruments are available at the author upon request.

photosynthesis during your student teaching training ?; (2) have you ever been trained in scoring students' answer sheets or homeworks? and (3) have you ever studied the topic of "diagnosing students' learning errors ?

In addition to the above three items, the respondents are asked to write their names, sex, date of brith, and the affiliated university. This data form is validated by a panel of 3 judges (2 science educators and one educational measurement specialist) who were of the opinion that the form is capable of elicting the kind of information being sought by the investigator. The reliability of PEDF was determined by the test-retest method on a random sample of 40 prospective teachers drawn from the Biology Section, College of Education, Azhar University, Egypt. The intervening period between the test and the retest were about three weeks. Correlation coefficients of .73, .70, .76 ($P < 0.5$) were obtained as reliability coefficients of items 1,2 and 3 respectively. No time limit is set for the administration of that form. However it took the subjects 3-5 minutes to fill it out.

The Photosynthesis Achievement Test (PAT)

This test was constructed to measure subjects' background knowledage about photosynthesis. It includes 22 free response

items. These items are intended to measure the basic propositions related to the topic of photosynthesis. These propositions were developed previously by Treagust & Haslam (1986). Teachers' achievement of these propositions were measured on the first three levels of Bloom's Taxonomy of educational objectives : The cognitive domain (Bloom, 1956). That is to say, knowledge, comprehension, and application.

Examples of test items follows :

1. Define the process of photosynthesis ?

2. Describe briefly the basic chemical reactions of photosynthesis. Name the raw material and end product of each reaction.

3. In two columns, contrast photosynthesis and respiration in as many ways as you can.

A jury of 3 educators, two science educators and a college botanist evaluated each test item and made suggestions for improvement. The evaluation criteria the jury used were brevity, clarity, vocabulary level, scope and content validity. Preliminary testing of this instrument was carried out on the same sample used for the pilot testing of the first instrument (the FEDF). This preliminary testing permitted further refinement of the instrument. The reliability of this instrument computed by coeffienct alpha (Cronbach, 1951) was found

to be (.77, $P < 0.5$). An answer key of the test items was developed by a botanist who teaches plant physiology course at the college level. This key includes model answers for the items. Subjects' answer to each item is weighted as follows : zero for no response or complete misunderstanding, 0.5 for partial understanding and one point for sound understanding. The range of the raw score is 0-22. The test was timed at 40 minutes.

The Identifying & Correcting Misconception Scale (ICMS).

This instrument was designed mainly to collect data about Teachers' competencies in identifying and correcting misconceptions about photosynthesis. Also, it collects data about Teachers' awareness of the possible reasons causing these misconceptions and of the instructional techniques whereby teachers can correct students' misconceptions.

The ICMS includes three sections : (1) an introduction; (2) a written answer; and (3) performable tasks. The introduction section perovides the reader with a general idea about the instrument, its purpose, and how to respond to it. This introduction also includes an explanation of the term misconception dermonstrated by examples from the topic of "digestion".

The written answer section is about one page handwritten essay type answer (about 135 Arabic words). This answer is prepared by this investigator as a representive of secondary school students' explanation of the following question : "Describe briefly, in one page, the process of photosynthesis. Ten misconceptions covering all aspects of this process are embedded in that answer (see table 1). Three sources were used to gather these misconceptions : 1) written sheets of fifty secondary school students who were asked to answer the above question; 2) interviews with three experienced biology teachers who were asked about the common misconceptions of photosynthesis among students; and 3) previous studies carried out on students' misconceptions about photosynthesis (e.g., Anderson et al., 1986; Treagust & Haslam, 1986).

The performable task section includes three tasks. For task # 1, the respondents are asked to write in a numerical order the statement of any misconception subsisted in that written answer. They are also asked to write the correct statement of the misconception. The style of stating the misconception and its correction is shown to the reader. Written example statements of two misconception about digestion and their corrections are provided first for this purpose.

An answer key for task ≠1 was prepared by this investigator with the help of two college botanists and three biology teachers. This key includes the statements of the ten misconceptions and their corrections (Table 1). The scoring system set for this task is that the respondent is given one point for every misconception he identifies successfully and another point for the misconception he can correct right. A zero point is given otherwise. Two total scores (ranged from 0-10) are computed for task ≠1. The first one, the total number of the misconceptions identified successfully, is the index of competency of identifying misconceptions. While the second total score, the total number of misconceptions corrected right, is the index of the competency of correcting misconceptions.

In task two, respondents are asked to write down in a numerical order all possible justications or reasons for student's misconceptions in photosynthesis. As for task three, the respondents are informed to set down in a numerical order the different instructional techniques Whereby teachers can correct these misconceptions on the part of students.

After each of the three tasks the respondents are given enough blanks in order to respond in writing to the task.

Pilot testing of this scale (ICMS) was administrated to the same forty subjects who participated in computing the reliability of the first instrument (FIDF). The subjects were asked to respond to the above three tasks and express their opionions on the clarity of this instrument by underlining any unclear words. Accordingly, few statements were revised. Then the scale(ICMS) was readministered to the same pilot testing sample after about 3 weeks. Four test-retest reliability coefficients were computed for the scale. Two reliability coefficients to the first task; one for identifying the misconceptions ($\underline{r}$ = .70, $\underline{P}$ <0.5) while the other is for correcting these misconceptions ($\underline{r}$ = .72, $\underline{P}$ < 0.5). The reliability coefficients for task # 2 and 3 were found to be.66, and.63 ($\underline{P}$ < 0.5) respectively. The content validity of the scale was determined by a panel of 3 judges (two science educators and one specialist in educational measurement). A roughly time limit of 25 minutes was set for administring the scale. This time was the approximate average time taken by five experienced biology teachers to complete this scale.

The Group Embedded Figures Test (GEFT)

This test was developed by Witkin et al. (1971) to measure the degree of field-independent/field-dependent cognitive style among individuals of age 10 and over. The test booklet contained

25 complex figures plus two simple figures. Eight simple figures were printed on the back cover of the booklet, and each of these was identified with a capital letter. The instruction to the subjects was to find a specified simple figure in each of the complex figures. The subjects were asked to trace the simple figure, using soft pencils which accompanied the test booklet. The test was then scored by visually comparing the traced simple figures with those provided in the scoring key. The test was divided into three parts consisting of 7, 9, and 9 items, respectively. The time limits for each portion are 2, 5, and 5 minutes, respectively. The first part, that was composed of 7 items, was not scored but it was intended as a rough screening device for comprehension. The number of simple figures correctly traced on the second and third parts constituted the raw score on the test. Thus, the range of raw scores may be 0-18. The reliability of the test computed by the Spearman-Brown formula was .82 for college students.

The Arabic form of GEFT, translated by Al-Sharkawy and Al-Sheikh (1985), was used to measure the cognitive style of the subjects. The manual of this Arabic form reports that the reliability coefficients of the GEFT computed by the Spearman-Brown Formula for the Egyptain male and female teacher education seniors were .76 and .78 respectively.

Procedure :

The following were the major steps employed to conduct this investigation.

(1) The four instruments of this study were administered in three sessions held on different days. The instruments of The Field Experience Data Form and The Photosynthesis Achievement Test were conducted on the first session. The Identifying & Correcting Misconception Scale and The Group Embedded Figures Test were administered in the second and third sessions respectively.

This sequence of adminstering these instruments might minimize the interaction effect resulted from conducting any of the first three instruments prior the other. All participating subjects completed the first three instruments. However only 159 subjects attended the last session in which The Group Embedded Figures Test was conducted. Because the subjects are drawn from two Colleges of Education, An attempt was made to administer the instruments in each college at a time. A science educator supervised the administration of the instruments in each college.

(2) The previously mentioned four instrumetns were handscored and double ckecked by the investigator.

(3) Research data collected were tabulated and then analyzed in the following steps :

3.1 Data drawn from the Identifying & Correcting Misconception Scale (ICMS) were sorted out as follows :

3.1.1. The freguency and percentage of subjects who succeeded in identifying and correcting each of the ten misconceptions were computed (see task ≠ 1 in ICMS).

3.1.2. Subjects' responses to task ≠ 2 and 3 were categorized. Each category was intended to include relatively similar responses.

3.2 Subjects' responses to the first two items of the Field Experience Data Form (FEDF) were coded. Each "yes" answer was designated (1) while the "no" answer is coded "Zero". Students' replies to item ≠ 3 were kept descriptive since they are not used in the analysis of the data. However, reference will be given to these replies latter in the discussion.

3.3 The Pearson-moment correlation matrix of all the variables of this study was computed by SAS-CORR computer program available at King Saud University Computer Center, Riydah, Saudi Arabia.

3.4 The muliple regression procedure was utilized to compute the squared multiple correlation coefficient (R^2) between each of the two competencies and the set of the four independent variables. This procedure was excuted by the SAS-REG computer program available at King Saud University Computer Center, Riyadh, Saudi Arabia. The main output of this program was the summary table of analysis of variance (F test) related to (R^2). Details about the multiple regression procedure are available elsewhere (e.g., Kerlinger & Pedhazur (1973),. Draper & Smith 1981).

3.5 The stepwise method was executed by SAS-STWPWISE computer program available at King Saud University Computer Center, Riyadh, Saudi Arabia. This method was used to select the best predictors of the competencies of identifying and correcting the misconceptions. The best variables, selected from the four independent variables mentioned befor were included in the stepwise prediction equation for each competency. The stepwise method basically employs a series of F tests to check the"significance" of the independent variables added to the prediction equation. In addition, the significance of variables

already in the equation is re-examined once new variables have been added. If they are not significant, they are deleted from the equation. More details about the stepwise method are available elsewhere (e.g., Draper & Simith, 1981).

It should be noted that the analysis of data by SAS-CORR, SAS-REG, and SAS-STEPWISE computer programs were carried out on 159 observations. Subjects with no scores in the Group Embedded Figures Test were deleted.

Results

The results of this investigation are presented in three sections. The first section describes results related to the assessment of subjects' competencies in identifying and correcting misconceptions. The second section includes results pertaining to the relationship of each competency to the set of the four independent variables mentioned before. Section three presents results related to the selection of the best predictors of each competency.

Section 1 : Results Related to the Assessment of Subjects' Competencies in Identifying and Correcting Misconceptions.

Three sets of findings are presented in this section. Each is related to one of the performable tasks included in the Identifying & Correcting Misconception Scale :

1.1 Findings pertaining to task≠1

Subjects were asked in this task to identify and then to correct in writing the misconceptions encountered in a students' answer about photosyethesis. Ten misconceptions were embedded in this answer. Table 1 reports the brief statements of these misconceptions and the associated correction statements. It also reports the frequency and percentage of subjects who succeeded in identifying and correcting each misconception.

Table 1 shows that : a) none of the misconceptions was identified or corrected by all subjects, b) for each misconception there is a discrepancy between the percentage of subjects who identied and corrected it. c) there is variation among misconceptions in the percentage of subjects who identifed or corrected them. d) out of the ten misconceptions, only four (1, 6, 7 and 9) were identified by fifty percent or more of the subjects; and (d) with the exception of misconception ≠9, all other misconceptions were corrected by less than fifty percent of subjects.

1.2 Findings pertaining to task≠2

Subjects who responded to task≠2 were asked to suggest all possible justifications or reasons for the formation of students' misconceptions in the topic of photosynthesis. Table 2 reports 22 suggested reasons. They are classified into three major categories : (a) students related reasons; (b) teachers related reasons; and (c) textbooks related reasons .Table 2 present also the frequency and percentage of subjects who suggested each reason. This table shows that : (a) the most frequent reasons are≠1 and 13 (b) more than half of the suggested reasons have been stated in general terms; (c) the reasons that are so specific to the formation of misconceptions in photosynthesis are 5, 9, 11, 16, 18, 20, and 22; and (d) none of the specific reasons was suggested by more than 15 % of subjects.

1.3 Findings pertaining to task≠3

Subjects responding to task≠3 were informed to propose different instructional techniques whereby teachers can correct the students' misconceptions about photosynthesis. Table 3 presents statements of 10 proposals in this respect. It also presents the frequency and

Table 1

Brief Statements of Misconceptions, Associated Corrections; and Frequency and Percentage of Subjects Succeeded in Identifying and Correcting each Misconception

NO.	Statement of Misconception	Misconception Identifcation		Statement of Correction	Misconception Correction	
		Frequency	Percentage		Frequency	Percentage
1	Photoysnthesis is the process whereby plants change solar rays into food.	100	50 %	Photosynthesis is the process whereby plants make their food from water and carbon dioxide in the presence of light energy trapped by the chlorophyll	71	35.5 %
2	Photosynthesis only takes place in plants' leaves.	57	28.5 %	Photosynthesis could take place in any parts of the plant containging chlorophyll (green leaves and stems).	55	27.5 %
3	Photosynthesis only takes place in green plants	10	5 %	Photosynthesis may take place also in some non-green plants such as seaweeds (brown and red algae), and Photsynthetic bacteria (Purple sulfur bacteria).	9	4.5 %
4	Water reacts directly to carbon dioxide during photosynthesis.	85	42.5 %	No direct reaction occurs between water and carbon dioxide. Each material goes through different pathways of reactions during the photosynthesis's process.	44	22 %
5	Photosynthesis takes place only in the presence of sun rays.	73	36.5 %	Photosynthesis takes place in the presence of light energy.	51	25.5 %
6	Chlorophyll is a green liquid substance.	11	65.5 %	Chlorophyll is a pigment in solution.	21	10.5 %
7	Chlorophyll helps to mix sun light with water and carbon dioxide during photosyntnesis.	115	57.5 %	Chlorophyll trap the lighe energy during photosynthesis.	80	40 %
8	Water + Carbon Dioxide $\xrightarrow[\text{Chlorophyll}]{\text{Light Energy}}$ Starch + Oxygen + Water	85	42.5 %	Water + Carbon Dioxide $\xrightarrow[\text{Chlorophyll}]{\text{Light Energy}}$ Carbohydrate + Oxygen + Water (hexose sugras)	70	35 %
9	Plants respire carbon dioxide.	143	71.5 %	Plants respire oxygen.	134	67 %
10	Starch is the food Whereby plants grow.	42	21 %	Glucose is the plant source of energy needed for growth, transport, reproduction, etc.	20	10 %

Table 2

Subjects' Suggested Reasons For Stuents' Misconptions about Photosynthesis in Terms of Frequency and Percentage
(N = 200)

Category	No	Suggested Reason	Frequency	Percentage
I. Students Related Reasons	1	Students do not study well the topic of photosynthesis	75	73.5 %
	2	Students misunderstand what is taught about photosynthesis.	48	24 %
	3	Stuents do not pay attention to teachers' exposition.	47	23.5 %
	4	Students do not use the scientific terms correctly in his answer	43	21.5 %
	5	Students conceptions about photosynthesis and respiration are mixed up.	30	15 %
	6	Students physical and psycho-logical conditions during the test (sickness, anxity, embarrassment, etc.)	21	10.5 %
	7	Students parrot the subject matter without understanding.	14	7 %
	8	Students are not interested in answering the question.	10	5 %
	9	Students have prior wrong ideas about photosynthesis resulted from their previous learning.	7	3.5 %
	10	Students are not intelligent.	6	3 %
	11	Students do not attain the cognitive developmental level needed for understanding the topic of photsynthesis.	5	2.5 %
	12	Students dislike Biology.	4	2 %

Table 2 (Continued) :

Category	No	Suggested Reason	Frequency	Percentage
II. Teachers' Related Reasons	13	Teachers do not explain the topic of photosynthesis well enough.	90	45 %
	14	Teachers do not use the scientific terms correctly during teaching.	37	18.5 %
	15	Teachers do not utilize experiments to explain the topic of photosynthesis.	20	10 %
	16	Teachers transfer their wrong information about photosynthesis to students.	10	5 %
	17	Teachers are not competent in the subject matter.	10	5 %
	18	Teachers do not try to diagnose student errors in the topic of photosynthesis.	7	3.5 %
	19	Teachers do not use visual aids to demonstrate the process of photosynthesis to students.	5	2.5%
	20	Teachers do not corret students' wrong information about photosynthesis.	4	2 %
III. Textbooks Related Reasons	21	Textbooks do not explain the topic of photosynthesis well enough.	10	5 %
	22	Textbooks contain erronous ideas about photosynthesis.	9	4.5 %

Table 3

Subjects' Proposals for Correcting students' Misconceptions in Terms of Frequency and percentage (N = 200)

No	The statment of the proposal	Frequency	Percentage
1	Teachers correct misconceptions by demonstrating experiments to students.	50	25 %
2	Teachers use scientific terms accurately.	44	22 %
3	Teachers discuss misconceptions with students then they give them the corrections.	40	20 %
4	Teachers reteach the topic of photosynthesis as a whole or part of it.	28	14 %
5	Teachers train students to use scientific terms accurately.	28	14 %
6	Teachers reteach the topic of photoynthesis using new methods of teaching other than the lecture method.	26	13 %
7	Teachers explain the difference between the photosynthesis and respiration to students.	22	11 %
8	Teachers test students frequently to diagnose their misconceptions.	18	9 %
9	Teachers help each student to correct the misconceptions by himself.	16	8 %
10	Teachers utilize visual aids to correct the misconceptions to students.	16	8 %
11	Teachers ask the students to read the textbook or other references to correct the misconceptions.	8	4 %
12	Teachers develop their acadmic capability in the subject matter.	7	3.5 %
13	Teachers pay attention to individual differences among students.	6	3 %
14	Teachers organize helpsessions to correct the misconceptions.	6	0.5 %
15	Teachers give students homworks.	1	0.5 %
16	Teachers refer to the errors in the textbook	1	0.5 %

percentage of subjects belonging to each category. Table 3 shows that : (a) the most frequent proposals are 1, 2 and 3, (b) more than half of the proposals are stated in general terms, and (c) few proposals are specifically applicable to the correction of misconceptions in photosynthesis, these are 3, 7, 11, 14, and 16.

Section 2 : Results Pertaining to the Relationship of Each Competency to the Set of Independent Variables.

This section includes descriptive statistics of the study's variables, and the correlation matrix of these variables. Then the results related to this relationship are presnted.

2.1 Descriptive statistics of the variables

This study includes two criterion and four independent variables as shown in table 4. This table includes also the mean, standard deviation and range of these variables as computed during running the SAS-CORR computer program.

Table 4

Variable Name, Type, Abbreviation, Mean, Standard Deviation and Range
(N = 159)

Variable Name	Variable Type	Variable abbreviation	Variable Mean	Variable S.D	Variable Range
Competency in Identifying Misconceptions	Criterion(1)	CIM	4.14	1.31	1-7
Competency in Correcting Misconceptions	Criterion(2)	CCM	2.85	1.25	0-7
Background Knowledge about Photosynthesis	Independent(1)	BKP	14.18	2.57	7-20
Field-Independent/Field-dependent Cognitive Style	Independent(2)	FI-FDCS	7.71	4.27	0-18
Previous Teaching Practice of Photosynthesis	Independent(3)	PTTP	0.25	0.44	0-1
Previous Experience of Scoring Student Assignments or Tests	Independent(4)	PESSST	0.52	0.50	0-1

2.2 Correlation matrix

Table 5 presents the Pearson product-moment correlation matrix of the study's variables. This matrix was the main output of the SAS-CORR computer program. Table 5 shows that the competency of identifying misconceptions (CIM) correlated significantly ($\underline{P} = < .0001$) and rather highly with the competency of correcting misconceptions CCM, ($\underline{r} = .78$) and background knowledge about photosynthesis, BKP, ($\underline{r} = .70$). None of the other independent variables correlated significantly with the competency of identifying misconceptions. The competency of correcting misconceptions, CCM, correlated significantly ($\underline{P} < .0001$) and rather highly with background knowledge about photosynthesis, BKP, ($\underline{r} = 0.74$). The field-independent / field dependent cogntive style (FI-FDCS) correlated significanly ($\underline{P} < 0.5$), but low with the competency of correcting misconceptions ($\underline{r} = .17$). None of the other independent variables correlated significantly with the competency of correcting misconceptions.

2.3 Findings pertaining to the relationship of each competency to the set of independent variables.

Table 5

Pearson Product-Moment Correlation Matrix
N = 159

CIM	CCM	BKP	FI-FDCS	PTPP	PESSST
CIM	0.78*	0.70*	0.13	0.01	0.09
CCM		0.74*	0.17**	0.02	0.14
BKP			0.16**	0.13	0.04
FI-FDCS				0.08	0.04
PTPP					0.24**

* P .0001
** P .05

The multiple regression procedure was used in this study to determine the over all relationship between each competency and a set of the independent variables. In other words this procedure was utilized to determine the over all prediction efficiency of the four independent variables (predictors) to predict each competency. Specifically this regression procedure was employed to test the following two null hypotheses :

(1) The competency of identifying misconceptions cannot be predicted ($\underline{P} < .05$) from the over all set of the independent variables.

(2) The competency of correcting misconceptions cannot be predicted ($\underline{P} < .05$) from the over all set of the independent variables.

The multiple regression procdure was executed by the SAS-REG computer program. This program provided an analysis of variance ($\underline{F}$ test) of the R-Square (R^2). Table 6 and 7 presents a summary table of the analysis of variance ($\underline{F}$ test) of the R-square Related to the competencies of identigying and correcting misconceptions respectively. The R^2 related to the first competency was found to be about .50 (table 6) and it was about .56 for the second competency (table 7).

Table 6

Analysis of Variance (F Test) of R-Square Related to the Competency of Identifying Misconceptions (CIM). (N = 159)

Source	df	Sum of Squares	Mean Squares	F-value	P> F	R-Square
Model	4	134.64	33.66	37.82	.0001	.4956
Error	154	137.04	.89			
Corrected Total	158	271.68				

Table 7

Analysis of Variance (F Test) of R-Square (R^2) Related to the Competency of Correcting Misconceptions (CIM). (N = 159)

Source	df	Sum of Squares	Mean Squares	F-Value	P> F	R-Square
Model	4	138.20	34.55	49.35	.0001	.5617
Error	154	107.98	0.70			
Corrected Total	158	246.18				

The two R-squares were found to be highly significant ($P < .0001$). So the previously stated two hypotheses were rejected. In other words the combined independent variables were successful in predicting the two competencies. These variables accounted for 50 % and 56 % of the variance of the competncies of identifying and correcting misconceptions respectively.

Section 3 : Results Pertaining to the Selection of the Best Predictors of the Competencies of Identifying and Correcting Misconceptions.

The stepwise method was used to select from the independent variables the best predictors of each competency. These best predictors were included in the prediction equation for each competency. Specifically this method was used to test the following two null hypotheses :

1. No specific subset of the independent variables is significantly ($P < .15$) superior to others in terms of the prediction efficiency to predict the competency of identifying misconceptions.

2. No specific subset of the independent variables is significantly ($P < .15$) superior to others in terms of the prediction efficiency to predict the competency of correcting misconceptions.

Table 8 and 9 List the independent variables selected by the stepwise method, as executed by SAS-STEPWISE computer program, for the competencies of identifying and correcting misconceptions respectively. These variables were selected in the order in which they entered the prediction equation, from those variables which provided the most significant prediction efficiency to that variables which provided the least significant additional prediction efficiency. The R-square was listed for each independent variable at the point of entery. Because of the interactive effect among the independent variables, the R-square changed each time an additional variables created a new prediction equation. The significance of adding variables to the equation was determined by the F statistic. This stepwise analysis ended with the variables included in the prediction equation associated with the partial regression weights (B_s). This final R-square always refers to the prediction efficiency of the prediction equation.

For the competency of identifying misconception, table 8 shows that the stepwise analysis resulted in selecting only one variable to be included in the prediction equation. That is the background knowledge about photosynthesis (BKP). Table 8 also indicates that the stepwise prediction equation

(raw score form) of this competency was :

$$Y = -0.909 + .356 \text{ (BKP)}.$$

The R-square associated with the above equation was .488.

Table 9 shows that three variables were selected by the stepwise analysis to be included in the prediction equation of the competency of correcting misconceptions . The background knowledge about photosynthesis (BKP) was selected in the first step. Then previous teaching practice of photosynthesis (PTPP), and previous experience of scoring students'assignment or tests (PESSST) entered the equation in the second and third steps respectively. The raw score formula of the stepwise prediction equation for the competency of correcting misconceptions was :

$$Y = -2.101 + .361 \text{ (BKP)} + .284 \text{ (PTPP)} + .20 \text{ (PESSST)}$$

The R-square associated with this equation was 0.56.

In short, the stepwise method resulted in selecting a specific subset of variables to be included in the prediction equation of the two competencies. Accordingly, it was concluded that the previously stated two hypotheses were rejected ($\underline{P} < .15$).

Table 8

Stepwise Regression procedure for the Competency of Identifying Misconceptions
(N = 159)

Step 1	Variable BkP entered	R-Square = .488	C(p) =	1.259	
	DF	Sum of Squares	Mean Square	F	P > F
Regression	1	132.618	132.619	149.73	0.0001
Error	157	139.054	0.886		
Total	158	271.673			
	B Value	STD Error	Type II SS	F	P > F
Intercept	-0.909				
BKP	0.356	0.029	132.619	149.73	0.0001

No other variables met the 0.1500 significance for entry into the model.

Table 9

Stepwise regression procedure for the Competency of Correcting Misconceptions
(N = 159)

Step 1	Variable BKP entered	R-Square = 0.540	C(p) =	6.512	
	DF	Sum of Squares	Mean Square	F	P > F
Regression	1	133.132	133.132	184.57	0.0001
Error	157	113.245	0.721		
Total	158	246.377			
	B Value	STD Error	Type II SS	F	P > F
Intercept	-2.215	0.026	133.132	184.57	0.0001
BKP	0.357				
Step 2	Variable PTTP entered	R-Square = 0.554	C(p) =	3.647	
	DF	Sum of Squares	Mean Square	F	P > F
Regression	2	136.543	68.272	96.97	0.0001
Error	156	109.834	0.704		
Total	156	246.377			
	B Value	STD Error	Type II SS	F	P > F
Intercept	-2.233				
PTPP	0.340	0.156	3.411	4.84	0.0292
BKP	0.364	0.026	136.414	193.75	0.0001
Step 3	Variable PESSST enterd	R-Square = 0.560	C(p) =	3.513	
	DF	Sum of Squares	Mean Square	F	P > F
Regression	3	138.049	46.013	65.83	0.0001
Error	155	108.338	0.6980		
Total	158	246.378			
	B Value	STD Error	Type II SS	F	P > F
Intercept	-2.101				
PESSST	0.200	0.1369	1.496	2.14	0.1454
PTTP	0.284	0.1588	2.231	3.19	0.0760
BKP	0.361	0.0261	133.443	190.92	0.0001

No other variables met the 0.1500 significance level for entry into the model.

Conclusions and Discussion

Based upon the findings, several conclusions can be drawn related to the problem investigated :

1. Conclusions Concerning the Assessment of the Pre-Service Biology Teachers' Competencies in Identifying and Correcting Misconceptions about Photosynthesis.

   1.1 It could be concluded from the relatively low precentage of subjects who indentified and corrected the misconceptions as shown in table 1 that the Egyptian population of pre-service biology teachers of this study are somewhat lacking the competencies of identifying and correcting misconceptions about photosynthesis. This low percentage of detecting or correcting misconceptions could be mainly attribuated to deficiency in the teachers' background knowledge about photosynthesis. Relatively high correlations were obtained in this study between this background knowledge and the competency of identifying misconceptions (r = .70) and the competency of correcting misconceptions (r = .74). See table 5 . It is possible that these pre-service teachers did not achive the basic propositions of the topic of photosynthesis. Accordingly they might not have built elaborated model answers whereby they judged and

corrected students' conceptions about this topic (see the theoretical framework for more details). Moreover, the teachers might hold misconceptions that are somewhat identical to those included in the written answer (table 1). Therfore they failed to see the misconceptions in that written answer as at variance with the scientifically accepted conceptions. It is worthwhile that this investigator has noticed during scoring the scripts of the subjects on The Photosynthesis Achievement Test that they possessed many misconceptions somewhat similar to those found in the student's written answer.

1.2 It could be concluded from the performance of the subjects on task ≠ 2 (table 2) that the knowledge of the Egyptian population of the pre-service biology teachers about the reasons of students' misconceptions is limited and equivocal. Most of the reasons as suggested by the subjects may have no intrepretative quality or a diagnostic value. The suggested reasons were of little compatibility with the reasons of the formation of the misconceptions as discussed by experts (e.g., Fisher & Lipson, 1986; Pines & West, 1986).

1.3 It could be concluded from the performance the subjects on task ≠ 3 (table 3) that this population of pre-service biology teachers is not aware of the instructional techniques whereby teachers use to correct students' misconceptions. Most of the subjects' proposals were lacking definite strategies of correcting the misconceptions. In addition, these proposals covered only few instructional techiques of correcting students' misconceptions as suggested by experts (See, e.g., Fisher & Lipson 1983, 1986; Roth & Anderson 1985, Pines and West, 1986).

The two conclusions : 1.2 and 1.3 may indicate that the population of Egyptain preservice biology teachers of this study have little knowledge of the diagnostic-remedial approaches of instruction (see Okey, 1974). These teachers did not study these approaches through the educational courses presented to them. That is infered from subjects' respenses to item ≠ 3 of "The Field Experience Data Form". Ninety-nine percent of the subjects declared that they had not studied the topic of "diagnosing students learning errors".

2. Conclusions Concerning the Relationship of the Competencies of Identifying & Correcting Misconceptions and the Set of the Independent Variables.

It could be concluded from the findings reported in table 8 and 9 that the prediction efficency of a set of the four independent variables was relatively moderate for the competency of identifying misconceptions (R^2 = .50) and for the competency of correcting misconceptions (R^2 = .57). This means that the combined four independent variables could explain 50 %, 57 % of the variance in the competencies of identifying and correcting misconceptions respectively. Still, a considerable percentage in this variance could not be attribuated to these independent variables. It seems that these competencies can be predicted from some other variables, too.

The relative success, achieved in this study for predicting the two competencies could mainly be due to the inclusion of the background knowledge about photosynthesis (BKP) among the independent variables. As expected, the BKP was found to correlate highly with the competency of identifying misconceptions (r = .70) and with the competency of correcting misconceptions (r = .74). See table 5.

On the other hand, the other independent variables were found to have low and insignificant ($P < .5$) relationships with the competency of identifying misconceptions. These low and insignificant relationships are unexpected and inconsistent with the theoretial framework of this study. Some explanations for these relationships go as fellows :

One possible explanation for the low and insignificant relationship of the field-independent/field-dependent cognitive style with the competency of identifying misconceptions (r = .13) is that the student's written answer mights include few articulated conceptions. Therefore, this cognitive style variable did not play its expected role (see the therorctial framework for more details about this role).

The very low and insignificant relationship between previous teaching practice of photosynthesis with the competency of identifying misconceptions (r = 0.013) and with the competency of correcting misconceptions (r = .002) could be attributed to one or more reasons. One possible reason is that the subjects who had this experience might have taught only few lessons in the unit of photosynthesis. Accordingly they did not have enough opportunity to encounter many of students' misconceptions in this unit. Another possible reason is that these subjects might have

spent most of the classtime lecturing to students. Hence they have little chance to listen to students' conceptions about photosynthesis. So they are left unaware of many of students' misconceptions in this topic.

A possible explanation of the very low and insignificant relationship of the previous experience of scoring students' assigniments or tests with the competencies of identifying and correcting misconceptions is that subjects who had this experience might have practiced it without a prior knowledge of the principles of scoring students' written answers. They might have thought that scoring these answers is limted to putting red marks and assign scores or grades to the answers. Perhaps these subjects were not taught that the scoring procedure includes also the detection of errors or misconceptions in students' answers. Accordingly, this previous experience of scoring students' answers seems to have no contribution to the competencies of identifying and correcting misconceptions.

3. Conclusions Related to the Selection of the Best predictors of the Competencies of Identifying & Correcting Misconceptions :

3.1 It could be concluded from the stepwise analysis that the background knowledge about photosynthesis is the best predictor of the competency of identifying misconceptions (see table 8).

3.2 Also, it could be concluded from the stepwise analysis that a specific subset of variables including the background knowledge about photosynthesis, previous teaching practice of photosynthesis, and previous experience of scoring students' assignment or tests was the best subset found in terms of the prediction efficiency for predicting the competency of correcting misconceptions.

It is possible that the superiority of the background knowledge as the best predictor of both competencies could be attributed to its high relationship with each competerncy (see table 5). In contrast, the noninclusion of other three independent variables, i.e., FI-FDCS, PTPP, PESSST in the prediction equation of the competency of identifying miscoceptions could be ascribed to the very low correlation obtained between each of these three variables and this competency (see table 5).

However, the stepwise method selected the previous teaching experience of photosynthesis and previous experience of scoring students' assignment or tests, as two of three best predictors of competency of correcting misconceptions, their contribution to the prediction efficiency of the prediction equation is very small (see table 9). Both variables correlated very low with this competency. Accordingly, discarding the two variables from this equation might have little effect on its prediction efficiency.

A possible explanation of the noninclusion of the feild-independent/field dependent cognitive style in the prediction equation of the competency of correcting misconceptions is that the relative contribution of this variable was confounding by the other three, variables, i.e., BKP, PTPP, PESSST, selected earlier in the steps of the stepwise method. Details about the confounding effect of some independent: variables on the selection of one other indpendent variable by the stepwise method are fully explained in Kerlinger and Pedhazur (1973)

Implications

First, the results of this investigation could imply that teacher training institutions should design training programs that develop the preservice teachers' competencies in diagnosing and correcting students misconceptions. Teachers in this programs may need to be acquainted with the diagnostic-remedial approaches of instructions. They may also perform some exercises that promote these competencies. These exercises could include students' answers and preformable tasks similar to those included in"The Identifying & Correcting Misconceptions Scale" or similar to the exercises developed by Nussbaum (1979). Moreover it is recommended that teachers in these programs be trained to apply the principles of scoring students'answer sheets.

Second, because of the high correlation found between the background knowledge about the topic of photosynthesis and both competencies, college botanists may require to change their approaches of teaching that topic to the prospective teachers. These botanists could concentrate on the basic propositions of that topic rather than teaching isolated facts about it.More important, they need to identify the misconceptions about this topic among those prespective teachers. The botainsts then can help them to correct these misconceptions. Fortunately, many effective approaches of

correcting misconceptions are now avaiable in the literature (see, e.g., Fisher & Lipson, 1983, 1986; Pines & West 1986).

Recommendation For Further Research

On the basis of the findings and conclusions previously discussed the following recommendation for further studies are suggested:

1. That similar studies be replicated in other teaching education istitutions which will help us to generalize the inference to the whole prospective science teachers.
2. That studies be conducted to investigate teachers' competencies in identifying and correcting misconceptions in other science school topics, e.g., heat, atoms, genetics, etc.
3. That studies be conducted to compare the competencies of identifying and correcting misconceptions of prospective science teachers with the inservice experienced teachers.
4. That studies be conducted to asses the competency of teachers in identifying misconceptions as occured in students' oral talk in the class.
5. That studies be designd to prepare training programs that promote teachers'competencies in indentifying and correcting misconceptions.

6. That studies be conducted to search for more of the teachers' variables that could be related to the competencies of identifying and correcting misconceptions.

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